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In Situ Bioremediation Remedial Action Groundwater Monitoring Plan for Test Area North, Operable Unit 1-07B

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October 2002

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Assistant Secretary for Environmental Restoration
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ABSTRACT

This groundwater monitoring plan (GWMP) supports the Operable Unit (OU) 1-07B In Situ Bioremediation Remedial Action Work Plan for implementing the final remedy for the OU 1-07B hotspot. The final hotspot remedy includes installing and operating an electron donor injection facility (consisting of a new injection well, injection equipment, on-site laboratory capabilities, and ancillary equipment), constructing two new groundwater monitoring wells, and monitoring groundwater at 13 existing locations and the two new monitoring wells. The hotspot remedy will be implemented in four phases: 1) interim operations, 2) initial operations, 3) optimization operations, and 4) long-term operations. These phases begin and end based upon conditions observed in the groundwater. As a result, remedy performance and compliance with remedial action objectives will be monitored under this plan throughout all implementation phases. This plan documents the procedures and rationale for groundwater monitoring to be conducted during each of the four phases. Data collected under this GWMP will be used to assess progress of the remedy, determine the need for operational changes, and support agency periodic performance reviews.

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ACRONYMS

CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
COC	chain of custody
DQO	data quality objective
EPA	Environmental Protection Agency
FLL	Field Lab Lead
FTL	field team leader
GWMP	Groundwater Monitoring Plan
ID	identification
INEEL	Idaho National Engineering and Environmental Laboratory
IRC	INEEL Research Center
ISB	in situ bioremediation
MCL	maximum contaminant level
O&M	operations and maintenance
OU	operable unit
PE	performance evaluation
QA	quality assurance
QAPjP	Quality Assurance Project Plan
RA	remedial action
RAO	remedial action objective
RAWP	Remedial Action Work Plan
SAP	Sampling and Analysis Plan
SMO	Sample Management Office
SRM	standard reference material
SRPA	Snake River Plain Aquifer
TAN	Test Area North

TBD	to be determined
TOS	Task Order Statement
TPR	technical procedure
TSF	Technical Support Facility
VOC	volatile organic compound
WAG	waste area group

In Situ Bioremediation Remedial Action Groundwater Monitoring Plan for Test Area North, Operable Unit 1-07B

1. INTRODUCTION

This groundwater monitoring plan (GWMP) supports the Operable Unit (OU) 1-07B In Situ Bioremediation (ISB) Remedial Action Work Plan (RAWP) for implementing the final remedy, as identified in the *Record of Decision Amendment for the Technical Support Facility Injection Well (TSF-05) and Surrounding Groundwater Contamination (TSF-23) and Miscellaneous No Action Sites Final Remedial Action* (DOE-ID 2001). The remedy entails installation and operation of an ISB lactate injection facility and two new monitoring wells. The injection facility consists of a new injection well, injection equipment, and on-site laboratory capabilities. The two new monitoring wells, PMW-1 and PMW-2, shall be located to provide crossgradient monitoring capabilities in the vicinity of TAN-28 and TAN-30A. Data collected in accordance with this GWMP will be used to assess progress of the remedy, determine the need for operational changes, and support agency periodic performance reviews.

Implementation of the OU 1-07B final remedy is defined in the *In Situ Bioremediation Remedial Action Work Plan for Test Area North Final Groundwater Remediation, Operable Unit 1-07B(Draft)* (DOE-ID 2002a). The ISB component of the remedy will be implemented in four phases (see Figure 1), as follows:

- **Interim operations**: This phase is a continuation of pre-design operational activities, including lactate injection and performance monitoring. It will also implement activities to evaluate alternate electron donors, develop injection monitoring strategies that will support initial operations, and refine the ISB simulation model. Interim operations will end when construction of the remedy is complete.

- **Initial operations**: This phase of remedy implementation will begin when construction is complete, and will focus on distributing electron donor adequately throughout the residual source area and cutting off downgradient contaminant flux of volatile organic compounds (VOCs) from the hotspot. Initial operations will be complete when VOC concentrations at TAN-28 and –30A (shown in the map of monitoring well locations in Figure 2) are below maximum contaminant levels (MCLs).

- **Optimization operations**: This phase will focus on maintaining adequate electron donor distribution to remediate the aquifer in the vicinity of the hotspot to risk-based levels, and cutting off crossgradient flux of VOCs from the hotspot. This phase of operations will be complete when VOC concentrations at PMW-1 and PMW-2 are below MCLs.

- **Long-term operations**: This phase will begin when electron donor is distributed throughout the residual source area. Continued ethene production will also be observed throughout this phase. This phase of operations will be complete when ethene production has ceased and VOC concentrations are below risk-based levels throughout the hotspot area.

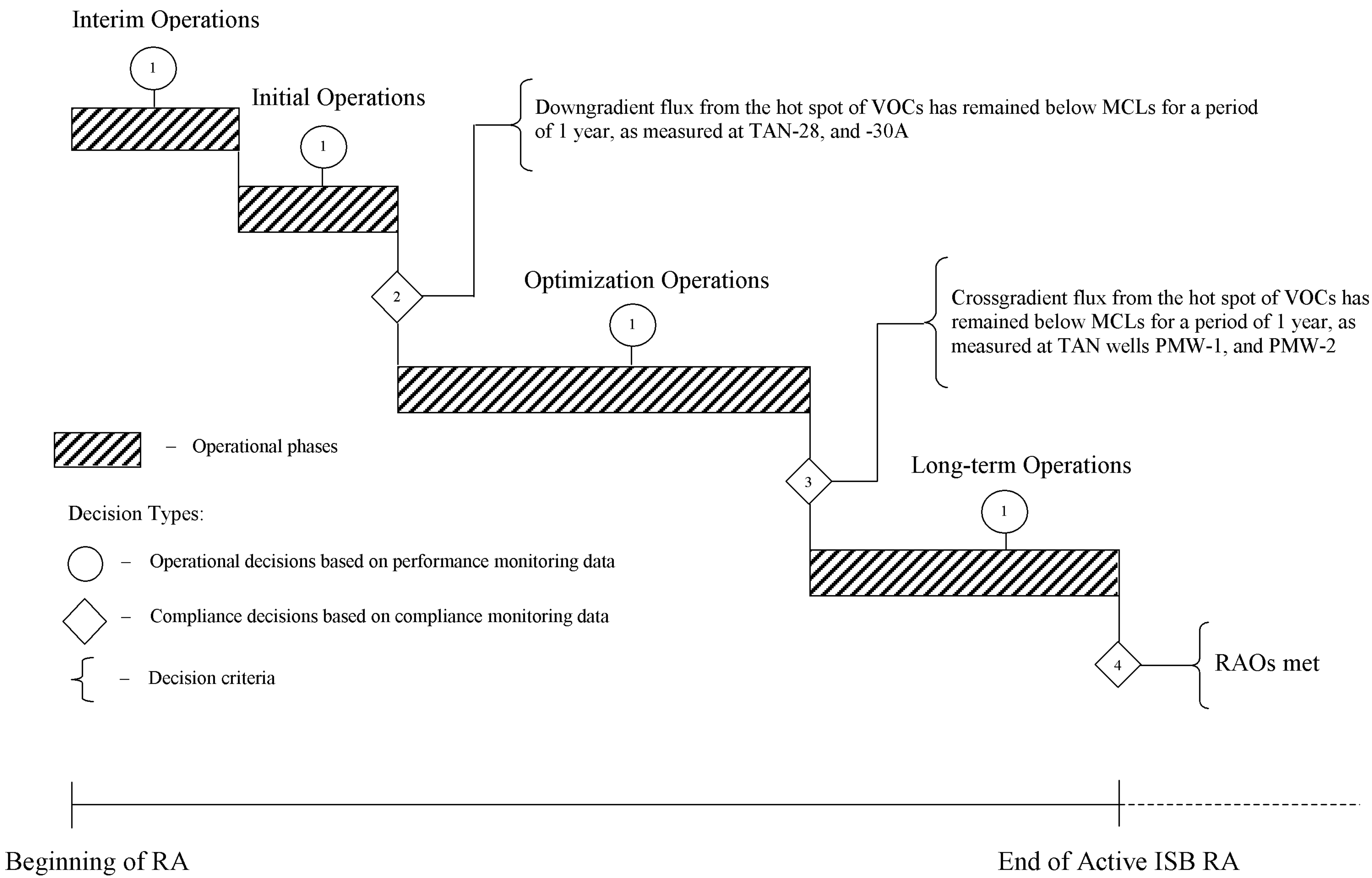

Figure 1. Remedial action implementation sequence.

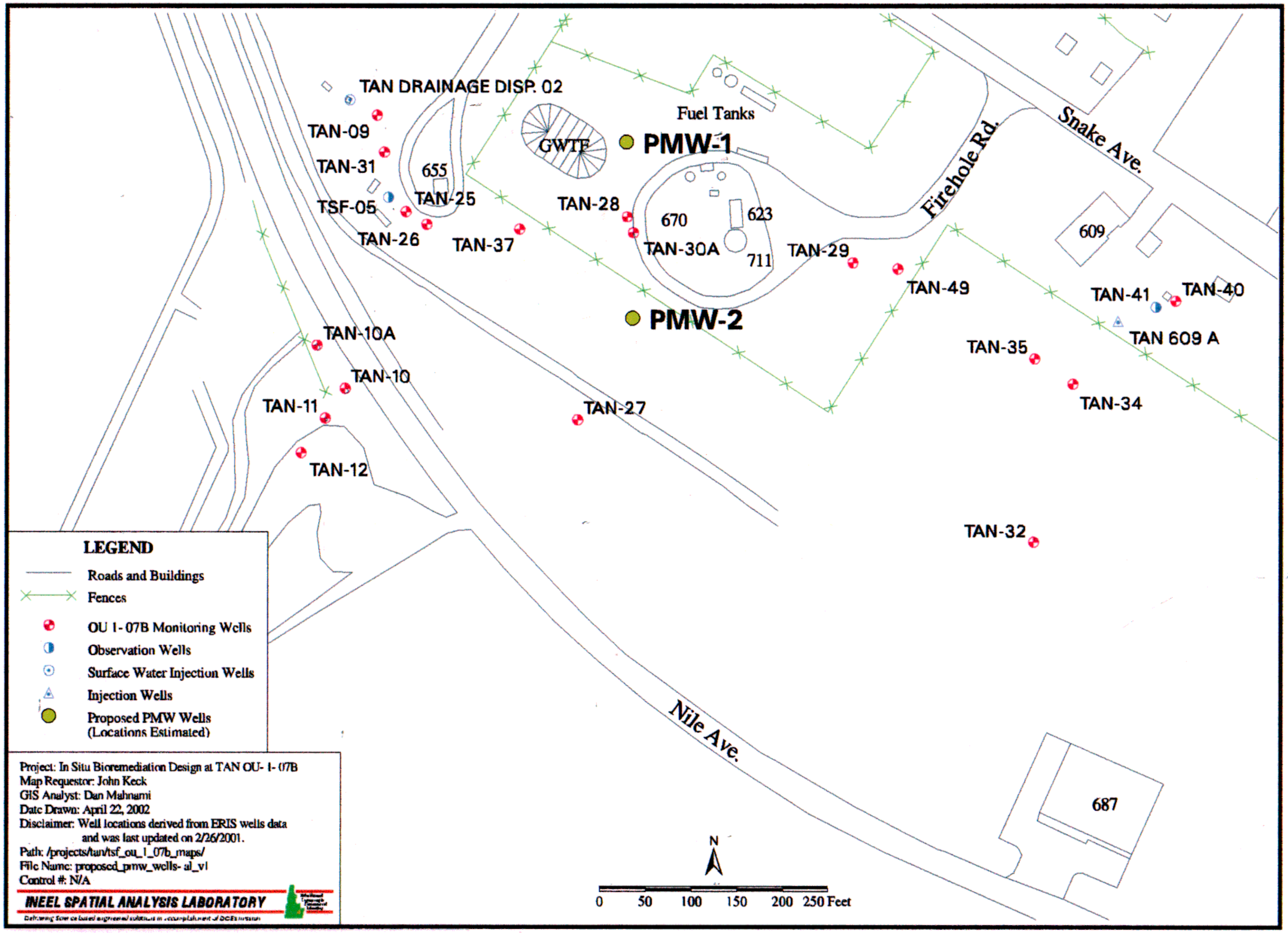

Figure 2. Source area monitoring well locations.

Figure 1 also shows the decisions to be made during remedy implementation including operational performance decisions and compliance decisions. Specific decisions corresponding to the numbers shown in Figure 1 include:

Decision 1 Determine, in each of the four phases, whether operational changes are required by routinely monitoring the performance of the ISB system with respect to indicator parameters including VOCs, tritium, Sr-90, Cs-37, gross alpha, ethene/ethane/methane, redox parameters, electron donor, bioactivity, and nutrients

Decision 2 Determine whether downgradient flux of contaminants from the hotspot has been cut off, as evidenced by VOC concentrations below MCLs at TAN-28 and -30A

Decision 3 Determine whether crossgradient flux of contaminants from the hotspot has been cut off, as evidenced by VOC concentrations below MCLs at PMW-1 and PMW-2

Decision 4 Determine whether long-term operations are complete (the compliance criteria for long-term operations will be specified in the ISB Remedial Action Report).

Groundwater monitoring data are required during each phase of remedy implementation to support the decisions listed above. This GWMP implements the Environmental Protection Agency (EPA) data quality objectives (DQOs) process, which was used to design and implement a data collection plan to acquire the required data at quality levels appropriate for data uses for each phase. DQO development is discussed in detail in the ISB RAWP (DOE-ID 2002a) and summarized in Section 2 of this GWMP. Following discussion of the DQOs, this GWMP presents the monitoring strategy for ISB, and defines the protocols to be used for groundwater sample management (i.e., collection, handling, and analysis), data management, and quality assurance (QA) activities associated with the ISB remedial action. This GWMP does not specifically address data collection for other OU 1-07B remedy components, which include pump-and-treat of the medial zone and monitored natural attenuation of the distal zone. However, data collected as part of ISB remedy implementation may be used by other remedy components to fulfill their respective data needs.

Supporting information for this GWMP is contained in Appendices A and B. Appendix A contains examples of the Sampling and Analysis Plan (SAP) tables that will be created for each sampling event to implement the sampling strategy. Actual SAP tables for each reporting period will be compiled in the ISB Periodic Report. Appendix B contains construction details for the monitoring wells that will be sampled.

1.1 Site Background and Hydrogeology

The TSF-05 injection well was used from 1953 to 1972 to dispose of liquid waste streams generated by operations at Test Area North (TAN). These waste streams included low-level radioactive wastewater, industrial wastewater including dissolved (and possibly pure) organic liquids, and sanitary sewage. The practice of waste injection into the Snake River Plain Aquifer (SRPA) resulted in a nearly 3-km (2-mi) long plume of contamination. Detailed descriptions of the historical background can be found in the Remedial Investigation Report (Kaminski et al. 1994) and in the Record of Decision (ROD) (DOE-ID 1995). The contaminants of concern in groundwater at the site include the VOCs trichloroethene (TCE), tetrachloroethene (PCE), trans-1,2-dichloroethene (trans-1,2-DCE), and cis-1,2-dichloroethene (cis-1,2-DCE), as well as the radionuclides tritium (H-3), strontium-90 (Sr-90), cesium-137 (Cs-137), and potentially uranium-234 (U-234). Figure 3 shows the contaminant plume and its location with respect to the Technical Support Facility (TSF).

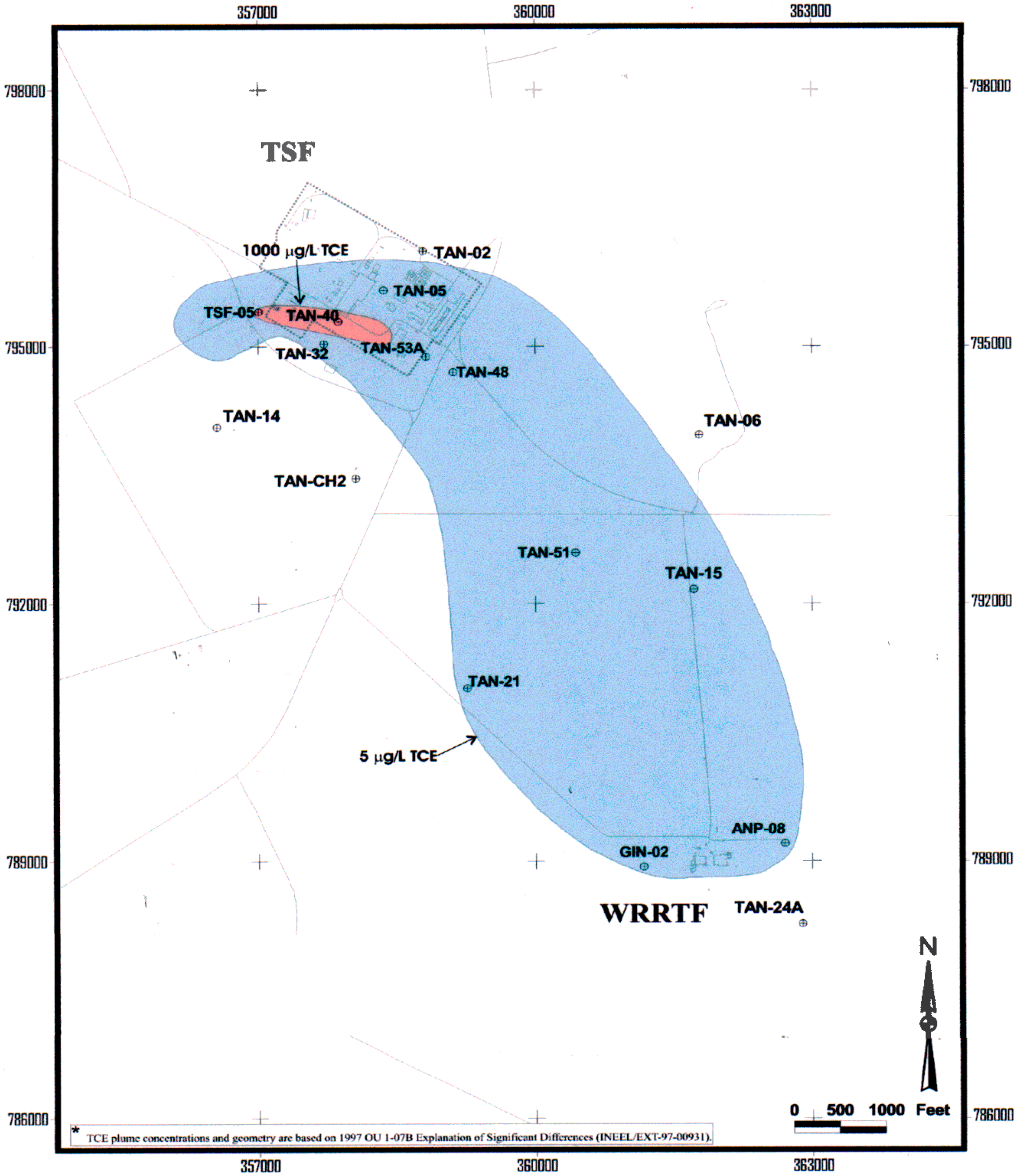

Figure 3. Contaminant plume at TAN.

The SRPA underlying TAN is composed of a complex layering of fractured basalt flows and sedimentary interbeds deposited during prolonged periods of volcanic quiescence. Depth to water in the vicinity of TAN is approximately 64 m (210 ft). The most significant recharge feature with respect to the groundwater contamination at TAN is a disposal pond west of Well TSF-05. Constructed in 1971 for disposal of the liquid waste streams previously discharged to the TSF-05 injection well, this pond receives on average about 104,300 L (27,550 gal) per day and 3.17 million L (838,000 gal) per month of wastewater based on 2001 operating records. Recharge from this pond is believed to play a significant role in the eastward migration of TCE from Well TSF-05 (Sorenson et al. 1996).

The aquifer at TAN appears to be unconfined, although locally confined conditions may exist due to the presence of sedimentary interbeds or dense, relatively impermeable basalt flows. The most significant sedimentary interbed at TAN occurs at about 125 m (410 ft) below land surface (bls) at Well TSF-05. This interbed ranges in thickness from about 2.4 m (8 ft) to more than 6 m (20 ft) and is laterally continuous and extensive. All evidence gathered to date suggests that this interbed effectively isolates the aquifer below it from the water above it. It is important to note that the interbed slopes at about one degree in a southerly direction, thus the thickness of the aquifer above the interbed at TAN increases from about 61 m (200 ft) near Well TSF-05 to more than 91 m (300 ft) at the leading edge of the TCE plume.

The TCE plume within the aquifer is stratified near the source area, with the highest concentrations in the upper portions of the aquifer. Several conceptual model reports published since extensive characterization work has been conducted detail the understanding of stratigraphy, aquifer behavior and TCE plume dynamics (Bukowski and Sorenson 1998; Bukowski et al. 1998; Wymore et al. 2000).

1.2 Description of Remedial Action

In situ bioremediation was identified in the OU 1-07B ROD Amendment (DOE-ID 2001) as the remedy for the hotspot, which was defined in 1998 as that portion of the contaminant plume with TCE concentrations greater than 20,000 ug/L (DOE-ID 1995). ISB takes advantage of naturally occurring bacteria that break down contaminants during metabolism of a food source. The particular application of ISB at TAN requires injection of an electron donor (i.e., sodium lactate, whey, or molasses) into the secondary source area. This amendment increases the number of bacteria, thereby increasing the rate at which the VOCs break down into non-hazardous compounds. This technology destroys the organic compounds in the hot spot without bringing them aboveground, preventing risk to workers and the environment. Based on actual field evaluations, ISB also degrades the secondary source. Degradation products generated by the bioremediation process (e.g., DCE and vinyl chloride) are degraded by the same process to ethene, chloride, water, and carbon dioxide.

Application of the ISB remedy at TAN will occur in the four phases described above, which are shown graphically in Figure 1 and described in detail in the ISB RAWP (DOE-ID 2002a). These phases begin and end based upon conditions observed in the groundwater. For this reason, groundwater monitoring is a necessary component of the remedial action. This plan documents the procedures and rationale for groundwater monitoring to be conducted during each of the four phases. ISB operations and maintenance (O&M) for implementation of these four phases are addressed separately in the *ISB Operations and Maintenance Plan for Test Area North, Operable Unit 1-07B* (DOE-ID 2002b).

2. DATA QUALITY OBJECTIVES

Development of DQOs for the ISB component of the remedy is presented in detail in the ISB RAWP, and is summarized in this section. The DQOs have been prepared based on decisions requiring groundwater monitoring data, as well as on EPA DQO guidance (EPA 1994), method detection limits, and experience with the sampling and analysis methods to date. Requirements for data quality for all Idaho National Engineering and Environmental Laboratory (INEEL) Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) investigations and remedial responses are defined in the *Quality Assurance Project Plan for Waste Area Groups 1, 2, 3, 4, 5, 6, 7 and 10* (DOE-ID 2000).

Decisions requiring groundwater monitoring data (see Figure 1) are listed in Section 1. The compliance decisions are based on the remedial action objectives (RAOs) and performance criteria for the ISB component of the remedy, as discussed in the RAWP. The operational decisions are based on performance indicators developed during 4 years of field evaluation at OU 1-07B, as described in the OU 1-07B ISB O&M Plan (DOE-ID 2002b). Application of the DQO process to these decisions has resulted in the data collection program described in Section 3.

3. DATA COLLECTION PROGRAM

This section describes the program designed to collect data at the appropriate locations, frequencies, and quality levels required to support decisions 1 through 4 listed in Section 1. It also contains details of the data collection program including sampling strategy, equipment, and procedures that support implementation of the ISB remedy component.

3.1 Sampling Strategy

The ISB sampling strategy for monitoring the status of the ISB remedy is based on the results of the DQO process and the experience gained from over 4 years of ISB field evaluation and pre-design operations. Two types of monitoring (i.e., performance and compliance) are defined and a detailed discussion of the specific indicator parameters for both types of monitoring is provided in the OU 1-07B ISB O&M Plan (DOE-ID 2002b).

Tables 1 and 2 portray the performance and compliance monitoring strategies, respectively, for the four operational phases. Monitoring strategy information includes monitoring locations, analytes, sampling frequencies, and data quality levels. Data quality levels are fully defined and their application is discussed in the Quality Assurance Project Plan (QAPjP) (DOE-ID 2000), as well as in the DQO development discussion in the RAWP. Definitive data have been required to date for assessing completion of remedial actions at the INEEL, and this data quality level is cited for ISB compliance monitoring for initial optimization and long-term operations. In general, definitive level data are generated using rigorous analytical methods such as approved EPA or American Society of Testing and Materials [ASTM] methods. Either analytical or total measurement error must be determined. Definitive data QA/QC elements include (DOE-ID-2000):

- Sample documentation, e.g., location, date, time
- Chain of custody
- Sampling design approach
- Initial and continuing calibration
- Determination and documentation of detection limits
- Analyte or property identification
- QC blanks (field and method)
- Matrix spike recoveries
- Analytical error determination. One sample will be analyzed in replicate and the mean and standard deviation determined and reported.
- Total measurement error determination. Replicate samples will be collected at one sampling location in each sampling round, analyzed, and the mean and standard deviation determined and reported.

Table 1. ISB remedial action groundwater performance monitoring strategy summary.

<table>
<tr><th rowspan="2">Monitoring Type/strategy element</th><th colspan="4">Operational Phase</th></tr>
<tr><th>Interim</th><th>Initial</th><th>Optimization</th><th>Long-term</th></tr>
<tr><td>Decision number</td><td colspan="4">1</td></tr>
<tr><td>Monitoring locations</td><td>TSF-05A, TSF-05B, TAN-10A, TAN-25, TAN-26, TAN-28, TAN-29, TAN-30A, TAN-31, TAN-37A, TAN-37B, TAN-37C, and TAN-D2.</td><td colspan="3">TSF-05A, TSF-05B, TAN-10A, TAN-25, TAN-26, TAN-28, TAN-29, TAN-30A, TAN-31, TAN-37A, TAN-37B, TAN-37C, and TAN-D2, PMW-1, PMW-2</td></tr>
<tr><td>Monitoring frequency/ Analytes</td><td colspan="3">Monthly: VOCs (PCE, TCE, cis- and trans-DCE, vinyl chloride), electron donors (COD, lactate, acetate, propionate, butyrate), redox parameters (ferrous iron, sulfate), bioactivity parameters (alkalinity), dissolved gases (ethene, ethane, methane), and tritium.

Quarterly: Sr-90, Cs-137 (TAN-29 only); definitive confirmation for VOCs and ethane/ethane/methane

Semiannual: Nutrients (ammonia-nitrogen, phosphate)

Annual: Gross alpha</td><td>Quarterly: VOCs (PCE, TCE, cis- and trans-DCE, vinyl chloride), electron donors (COD, lactate, acetate, propionate, butyrate), redox parameters (ferrous iron, sulfate), bioactivity parameters (alkalinity), dissolved gases (ethene, ethane, methane), and tritium; Sr-90, Cs-137 (TAN-29 only)

Semiannual: Nutrients (ammonia-nitrogen, phosphate)

Annual: Gross alpha; definitive confirmation for VOCs and ethane/ethane/methane</td></tr>
<tr><td>Data quality required[a]</td><td colspan="4">Screening w/definitive confirmation for VOCs and ethane/ethane/methane

Definitive for radionuclides and definitive confirmation for VOCs and ethane/ethane/methane

Screening for all other analytes</td></tr>
<tr><td>Data validation level required[b]</td><td colspan="4">Level A for VOC and ethane/ethane/methane definitive confirmation and radionuclide analyses

No data validation for on-site and IRC laboratory data</td></tr>
</table>

a: Data quality levels are defined in the QAPjP.
b: Data validation levels are defined in the QAPjP.

Table 2. ISB remedial action groundwater compliance monitoring strategy summary.

Monitoring Type/Strategy Element	Operational Phase			
	Interim	**Initial**	**Optimization**	**Long-term**
Decision number	N/A	2	3	4
Monitoring duration	N/A	1 year		TBD
Monitoring frequency	N/A	Quarterly		TBD
Monitoring locations	N/A	TAN-28 TAN-30A	PMW-1 PMW-2	TBD
Analytes	N/A	VOCs (PCE, TCE, cis- and trans-DCE, vinyl chloride)		TBD
Data quality required[a]	N/A	Definitive		TBD
Data validation level required[b]	N/A	Level A		TBD

a: Data quality levels are defined in the QAPjP.
b: Data validation levels are defined in the QAPjP.
N/A: Not applicable
TBD: To be determined

Screening level data (generated using rapid, less precise analytical methods with less rigorous sample preparation) are cited for all performance monitoring indicators except VOCs, for which screening with definitive confirmation is specified. Screening with definitive confirmation is defined in the QAPjP as "…at least 10% of the screening data are confirmed using analytical methods and quality assurance/quality control (QA/QC) procedures and criteria associated with definitive data." Definitive confirmation will not be used for performance indicators that do not have action levels.

The overall OU 1-07B ISB remedial action performance and compliance monitoring sampling strategies are as follows:

- **Interim operations performance monitoring** (Decision 1): Includes monthly sampling for performance indicator parameters at 13 ISB locations listed in Table 1 for the duration of the phase. Monthly monitoring at the 13 existing locations during the ISB field evaluation and pre-design operations was found to effectively identify trends in parameters that indicate ISB system performance (INEEL 2000). Shorter-interval sampling for subsets of the performance indicators may be implemented, as directed by the ISB Operations Technical Lead, to observe transient conditions, for example, when testing electron donor injection strategies. This performance monitoring strategy also includes deploying and maintaining in situ multi-parameter monitoring probes, as directed by the ISB Operations Technical Lead.
- **Initial operations performance monitoring** (Decision 1): Includes monthly sampling for performance indicator parameters at 15 ISB locations (13 existing locations and planned monitoring wells PMW-1 and PMW-2) for the duration of the phase. This strategy incorporates monthly monitoring for VOCs at TAN-28 and -30A to determine downgradient contaminant flux trends. Similar to the interim operations performance monitoring strategy described above, shorter-interval

sampling for subsets of the performance indicators may be implemented as directed by the ISB Operations Technical Lead. This performance monitoring strategy also includes use of in situ multi-parameter monitoring probes in specific wells, as directed by the ISB Operations Technical Lead.

- **Initial operations compliance monitoring** (Decision 2): The strategy for determining when downgradient flux is cut off includes quarterly monitoring for 1 year at TAN-28 and TAN-30A for VOCs. This sampling will begin when performance monitoring indicates that VOC concentrations are below MCLs at TAN-28 and -30A. These sampling events will be coordinated with regular monthly performance sampling; the samples will be analyzed using definitive methods.

- **Optimization operations performance monitoring** (Decision 1): Includes monthly sampling for performance indicator parameters at 15 ISB locations (13 existing locations and planned monitoring wells PMW-1 and PMW-2) for the duration of the phase. The monthly sampling frequency will be continued in order to identify any trends requiring operational modifications. This strategy incorporates monthly monitoring for VOCs at PMW-1 and PMW-2 to determine crossgradient contaminant flux trends. Shorter-interval sampling for subsets of the performance indicators may be implemented as directed by the ISB Operations Technical Lead. This performance monitoring strategy also includes use of in situ multi-parameter monitoring probes in specific wells, as directed by the ISB Operations Technical Lead.

- **Optimization operations compliance monitoring** (Decision 3): The strategy for determining when crossgradient flux of contaminants from the hotspot is cut off includes quarterly monitoring for VOCs for 1 year at PMW-1 and PMW-2. This sampling will begin when performance monitoring indicates that VOC concentrations are below MCLs at PMW-1 and PMW-2. These sampling events will be coordinated with regular monthly performance sampling; the samples will be analyzed using definitive methods.

- **Long-term operations performance monitoring** (Decision 1): Includes quarterly sampling for performance indicator parameters at 15 ISB locations (13 existing locations and planned monitoring wells PMW-1 and PMW-2) for the duration of the phase. The ISB system will be functional and operational during this phase, with a defined operating strategy thereby reducing performance-sampling requirements. The number of monitoring locations and analytes may be reduced during this phase, as directed by the ISB Operations Technical Lead. Shorter-interval sampling for subsets of the performance indicators may be implemented as needed to observe transient conditions. This performance monitoring strategy also includes use of in situ multi-parameter monitoring probes in specific wells, as directed by the ISB Operations Technical Lead.

- **Long-Term Operations compliance monitoring** (Decision 4): The Remedial Action Report will establish the sampling strategy to define when the remedy is complete.

Table 3 defines analytical methods, action levels, method detection limits, and data quality levels for each analyte and each monitoring phase. All other sampling and analysis details, including container types, sample preservation, holding time, analytical methods, and chain of custody (COC) requirements, are addressed in Section 4.

Table 3. ISB remedial action analytical method summary.

Analyte	Action level[a]	Analytical method	Method Detection limit[b,c]	Monitoring phase or other data collection activity
VOCs				
TCE	5 ug/L	EPA 524.2 wide-bore capillary column	0.19 µg/L	Compliance
	N/A	SW-846 8260B	5 µg/L	Definitive confirmation
	N/A	SPME-GC-ECD	2 µg/L	Performance
PCE	5 ug/L	EPA 524.2 wide-bore capillary column	0.14 µg/L	Compliance
	N/A	SW-846 8260B	5 µg/L	Definitive confirmation
	N/A	SPME-GC-ECD	6 µg/L	Performance
cis-DCE	70 ug/L	EPA 524.2 wide-bore capillary column	0.12 µg/L	Compliance
	N/A	SW-846 8260B	5 µg/L	Definitive confirmation
	N/A	SPME-GC-ECD	2 µg/L	Performance
trans-DCE	100 ug/L	EPA 524.2 wide-bore capillary column	0.06 µg/L	Compliance
	N/A	SW-846 8260B	5 µg/L	Definitive confirmation
	N/A	SPME-GC-ECD	2 µg/L	Performance
vinyl chloride	2 ug/L	EPA 524.2 wide-bore capillary column	0.17 µg/L	Compliance
	N/A	SW-846 8260B	5 µg/L	Definitive confirmation
	N/A	SPME-GC-ECD	2 µg/L	Performance
Radionuclides				
Tritium	N/A	Liquid scintillation counting	400 pCi/L	Performance
Sr-90	N/A	Gas flow proportional	1 pCi/L	Performance
Cs-137	N/A	Gamma spectrometry	30 pCi/L	Performance
Gross alpha	N/A	Gas flow proportional	4 pCi/L	Performance
Electron donor				
Lactate	N/A	Ion chromatography	5 mg/L	Performance
Acetate	N/A	GC/FID	5 mg/L	Performance
Propionate	N/A	GC/FID	5 mg/L	Performance
Butyrate	N/A	GC/FID	5 mg/L	Performance
COD	N/A	Hach Method 10067	14 mg/L	Performance

Table 3. (Cont'd).

Analyte	Action level[a]	Analytical method	Method Detection limit[b,c]	Monitoring phase or other data collection activity
Redox indicators				
Sulfate	N/A	Hach Method 8051	4.9 mg/L	Performance
Iron	N/A	Hach Method 8146	0.03 mg/L	Performance
pH	N/A	Hydrolab	0-14 units	Performance
ORP	N/A	Hydrolab	-999-+999 mV	Performance
Bioactivity indicators				
Alkalinity	N/A	Hach Method 8203	10 mg/L	Performance
Specific conductivity	N/A	Hydrolab	0-100 mS/cm	Performance
Dissolved gases				
Ethene	N/A	GC-FID	1 ug/L	Performance
Ethane	N/A	GC-FID	1 ug/L	Performance
Methane	N/A	GC-FID	1 ug/L	Performance
Nutrients				
Ammonia nitrogen	N/A	Hach Method 10023 (for low range) Hach Method 10031 (for high range)	0.02 mg/L	Performance
Orthophosphate	N/A	Hach Method 8048	0.05 mg/L	Performance

a: Action levels apply only to compliance monitoring, for which chloroethene levels are compared to MCLs to determine end of phase.

b: Method detection limits for: EPA method organics and radionuclides from DOE (2000), *QAPjP for WAGs 1, 2, 3, 4, 5, 6, 7, 10 and Inactive Sites*; Hach methods from the Hach Manual; Hydrolab parameters ranges reported are from the Hydrolab Minisonde 4a manual; electron donor and SPME organics from IRC organics analyst Cathy Rae, personal communication.

c: For purposes of this groundwater monitoring plan, "Detection limits must not exceed one tenth the risk-based or decision-based concentrations for the contaminants of concern" (DOE 2000). This applies to compliance monitoring only. Chloroethene action levels were divided by ten and compared to the MDL to determine appropriate analytical methods for compliance monitoring.

3.2 Sampling Equipment and Procedures

Samples will be collected to implement the strategies summarized in Tables 1 and 2, per the SAP tables prepared prior to each sampling event by the Sample Management Office (SMO) under the direction of the ISB field team leader (FTL). Example SAP tables for each phase of operations and type of monitoring (performance or compliance) are presented in Appendix A. Sample collection activities will be performed by the FTL, Field Engineer, and sampling technicians. The general roles of each are defined in the *Test Area North Operable Unit 1-07B Final Groundwater Remedial Action Health and Safety Plan* (INEEL 2002a), while the specific responsibilities for each position are specified in the procedures referenced below.Sampling will be conducted using the equipment and techniques specified in TPR-165, "Low-Flow Groundwater Sampling Procedure." This procedure addresses training, equipment, instrument calibrations, purging, sampling, purge water management, decontamination and cleaning of equipment, and record keeping in support of this monitoring plan and will be updated as required for the duration of monitoring.

In situ multi-parameter monitoring probes will be used for collecting purge parameter data during sampling, and for in situ deployment in wells specified by the ISB Operations Technical Lead for the duration of the remedy implementation. In situ multi-parameter monitoring probes will be deployed, operated, and maintained as specified in the technical procedure (TPR) to be determined (TBD) for "In Situ Multi-Parameter Monitoring Probe Operations." This procedure addresses training, instrument calibration, programming and downloading, maintenance and repair, deployment and retrieval, and record keeping, and will be updated as required for the duration of monitoring.

Construction information for the OU 1-07B ISB monitoring wells is shown in Appendix B and is maintained in the OU 1-07B project files and the INEEL Hydrogeologic Data Repository. The information includes name, location, material type, depth, screened or open interval, top of casing elevation, pump type, discharge hose or pipe dimension, sampling depth, and estimated purge volume for each well (current as of the date of publication).

3.3 Waste Management

The sampling activities described above will generate potentially contaminated wipes, sample bottles, personal protective equipment (PPE), sample rinsates, and purge water. All wastes generated as a result of ISB groundwater monitoring activities will be managed in compliance with the requirements of the *Waste Management Plan for TAN Final Groundwater Remediation OU 1-07B* (INEEL 1999).

3.4 Health and Safety

Health and safety program requirements are addressed in the TAN OU 1-07B Health and Safety Plan (HASP) (INEEL 2002a). This HASP has been prepared to meet the Occupational Safety and Health Act (OSHA) standard for Hazardous Waste Operations and Emergency Response and governs all work performed as a part of ISB O&M.

4. SAMPLE MANAGEMENT AND ANALYSIS

The ISB final remedial action groundwater monitoring program includes three analytical components. These components include 1) onsite field analyses and measurements, 2) analyses performed at the INEEL Research Center (IRC), and 3) analyses performed at offsite laboratories. This section describes the protocols to be followed during all sample management (those activities immediately following sample collection) and analysis activities. The FTL is responsible for implementing all sample management protocols and the Field Lab Lead (FLL) is responsible for implementing all sample analysis protocols.

4.1 Sample Management

4.1.1 Sample Designation and SAP Tables

A character-based sample identification (ID) system determined by the SMO will be used to identify each sample with a unique ID code, which is provided by the SMO at the time the SAP tables are prepared. SAP tables will be used to record all pertinent information including monitoring locations, sample designations, media, dates, analysis types, and comments associated with each sample ID code. Example SAP tables for each monitoring phase are provided in Appendix A. In an effort to minimize SAP discrepancies, SAP tables will be prepared immediately prior to each sampling event and the completed SAP tables will be included in the ISB Periodic Report for the reporting period. The FTL is responsible for SAP table accuracy.

4.1.2 Sample Preservation and Preparation

Table 4 defines the analyses to be performed by the on-site field laboratory, IRC laboratory, and off-site laboratories. For each analyte listed, the container size and type, preservative, analytical method, and holding time is provided. Samples requiring 4°C preservation will be chilled in coolers containing frozen reusable ice immediately upon collection and maintained at a temperature ≤ 4°C prior to shipment to ensure adequate preservation.

Sample bottles will be preserved prior to sample collection for those samples requiring zero headspace (i.e., ethene/ethane/methane and VOCs analyzed off-site). Appropriate acid will be added (and the pH checked after sample collection) to obtain a pH between 1.6 and 2 for those samples requiring preservation at pH < 2 that do not require zero headspace. Samples analyzed offsite will be handled and preserved per the governing SMO Task Order Statement (TOS).

The priority indicated in Table 4 for field laboratory analyses is related to the holding times for those particular analyses. All of the field analyses will be performed per TPR-166, "ISB Analyses Procedure" within the stated holding time. Those with a priority of 1 or 2 will be analyzed as soon as possible after collection.

Table 4. Sample collection and analysis requirements.

Analytes	Sample container size and type	Preservative	Analytical Method	Holding time	Comments
IRC laboratory analyses					
VOCs	Two glass 40-mL VOA vials	4ºC	SPME-GC-ECD	7 days	No headspace
Ethene/ethane/methane	Two glass 40-mL VOA vials	4ºC and pH < 2 w/H_2SO_4	SW-846-8015M w/GC-FID	14 days	No headspace
Lactate	One glass 40-mL VOA vial	4ºC	Ion chromatography	7 days	
Acetate/Propionate/Butyrate	One glass 40-mL VOA vial	4ºC	GC/FID	7 days	
Field laboratory analyses (priority)					
Iron (1)	250-ml HDPE	none	Hach Method 8146	30 minutes	Must be analyzed immediately; collected in same container as sulfate: no headspace
Phosphate (2)	250-mL HDPE	4ºC	Hach Method 8048	24 hrs	Collected in same container as iron
Nitrogen, ammonia, low range (3)	250-mL HDPE	4ºC	Hach Method 10023	24 hrs	Collected in same container as iron

Table 4. (Cont'd).

Analytes	Sample container size and type	Preservative	Analytical Method	Holding time	Comments
Nitrogen, ammonia, high range (4)	250-mL HDPE	4ºC	Hach Method 10031	24 hrs	Collected in same container as iron
Alkalinity (5)	125-mL HDPE	4ºC	Hach Method 8203	24 hrs	
Sulfate (6)	250-mL HDPE	4ºC	Hach Method 8051	24 hrs	Collected in same container as iron
Chemical oxygen demand (7)	One glass 40-mL VOA vial	4ºC	Hach Method 10067	28 days	Initial sample preparation within 1 hour of arrival at field laboratory
Off-site laboratory analyses					
VOCs	Three glass 40-mL VOA vials	4ºC and pH<2 w/H_2SO_4 (8260B) or HCl (524.2)	SW-846 8260B or EPA 524.2 (see Table 2)	14 days	No headspace
Gamma screen	1-540 mL HDPE	None	Gamma spectrometry	N/A	Required for samples from TSF-05, TAN-25, -26, -31 prior to shipment off-site
Cs-137	1-2 L HDPE	HNO_3 to pH<2	Gamma Spectrometry	6 months	Collected at TAN-29 only
Sr-90	1-500 mL HDPE	HNO_3 to pH<2	Gas flow proportional	6 months	Collected at TAN-29 only
Gross alpha	1-500 mL HDPE	HNO_3 to pH<2	Gas flow proportional	6 months	

GC/FID = gas chromatography/flame ionization detection
HDPE = high-density polyethylene
VOA = volatile-organic analysis

4.1.3 Chain of Custody

To maintain and document possession of samples shipped to a laboratory for analysis, COC procedures will be followed per MCP-3480, "Environmental Instructions for Facilities, Processes, Materials and Equipment" and the QAPjP (DOE-ID 2000). The purpose of the COC is to document the identity of the sample and its handling from the point of collection until laboratory analysis is complete. The COC record is a multiple copy form that serves as a written record of the sample handling. When a sample changes custody, those personnel relinquishing and receiving the sample shall sign a COC record. Each change of possession will be documented. The COC procedures will begin immediately after sample collection. The sample ID number, date, and time will be entered on the COC form the day of sample collection. Sample bottles will be stored in a secured area accessible only to the field team members. A COC will not be initiated for those samples that are analyzed onsite in the field laboratory unless specified by the FTL or FLL, since these samples will not leave the custody of the field team members.

4.1.4 Transportation of Samples

Samples will be transported in accordance with the regulations issued by the Department of Transportation (49 CFR Parts 171 through 178) and EPA sample handling, packaging, and shipping methods (40 CFR 261.4[d] and [e]). All samples will be packaged in accordance with the requirements set forth in MCP-3480 and the governing TOS.

4.1.5 Radiological Screening

Samples collected from wells TAN-25, -26, -31, and TSF-05 must be surveyed using gamma spectrometry prior to analysis or shipment off-site. Radioactivity in all other wells to be sampled has historically been below levels of concern. Samples collected from other wells may be surveyed using gamma spectrometry under the direction of the Technical Lead, FTL, or Operations Supervisor.

4.2 Sample Analysis

Sample analysis will be conducted using three analytical components (i.e., the on-site field laboratory, the IRC laboratory, and SMO-appointed off-site laboratories) dependent upon holding time restrictions, analytical capabilities, and quality level requirements. Analytes and the analytical methods to be used for each of the three components are defined in Table 4. Quality assurance requirements associated with the activities taking place within each of the three components are described separately in Section 6. The on-site field laboratory, in addition to providing analytical resources, is also used for sample preparation activities in support of analyses to be conducted at both the IRC and off-site laboratories. A summary description of the laboratory activities is provided below.

4.2.1 On-site Field Laboratory Activities

The field laboratory supports ISB project team activities for all three analytical components of the monitoring program. The field laboratory is the center for all onsite data collection activities including field test kits, in situ multi-parameter monitoring probe data, and purge data. These activities provide near real-time data for evaluating the performance of the ISB remedy. In addition, the field laboratory is used for coordinating sample delivery to the IRC and for sample shipment to offsite laboratories, as described in Sections 4.1.1 through 4.1.5. Specific activities that the field laboratory supports include colorimeter operation, digital titrator operation, gross alpha-beta counts, and sample packing and shipping; in situ multi-parameter monitoring probe deployment, maintenance, calibration, and downloading; and sample bottle preparation and administrative activities.

Field laboratory operations will be conducted by the FTL, FLL, Field Lab Technician, and In Situ Multi-Parameter Monitoring Probe Technician. The general roles of each are defined in the ISB HASP, while specific responsibilities are specified in the relevant procedure(s). Field laboratory operations and associated equipment are described in TPR-166, "ISB Analyses Procedures." In situ multi-parameter monitoring probe deployment, maintenance, calibration, and downloading will be conducted using the equipment and techniques described in a TPR (TBD). These procedures will be updated as required for the duration of monitoring.

4.2.2 IRC Laboratory Activities

Analysts at the IRC laboratory analyze samples for chloroethene, ethene/ethane/methane, dissolved gases, lactate, and organic acids using the methods listed in Table 4. IRC laboratory operations utilize one to two analysts in support of ISB groundwater monitoring operations. The IRC analyst roles are generally defined in the ISB HASP, while specific responsibilities, methods, equipment, and requirements are defined in TPR-166 as well as in Section 6.

4.2.3 Off-site Laboratory Activities

Off-site laboratories analyze samples for chloroethenes, ethane/ethane/methane, Cs-137, Sr-90, gross alpha and tritium using definitive methods. Specific requirements are defined in the TOS prepared by the INEEL's SMO for each analytical services subcontract.

5. DATA MANAGEMENT AND REPORTING

This section provides an overview of the process used for entering, compiling, and storing data collected in support of the ISB remedy activities. The detailed steps of the data management process are documented in a TPR (TBD) for ISB Data Management; the process is shown graphically in Figure 4.

Data are obtained from the following sources: the field laboratory (logbooks), in situ multi-parameter monitoring probes (electronic files and purge log sheets), the IRC Laboratory (electronic data files), and off-site laboratories (off-site data packages from the SMO). Upon receipt of data from these sources, data are compiled and entered into electronic spreadsheets. Spreadsheets are organized according to the data types presented above, updated with new data consistent with respective sampling frequencies, and posted to the OU 1-07B server. Once posted to the server, the completed spreadsheets are used to evaluate data in the context of progress toward the objectives of the remedy, as described in detail in the ISB O&M Plan (DOE-ID 2002b).

Reporting requirements for ISB groundwater monitoring results are defined in the RAWP. All ISB groundwater monitoring information will be compiled in the ISB Periodic Report and will be provided to the agencies. Information reported will include analytical results, SAP tables, trend charts, QA results, interpretations, and operational changes. The Periodic Report will document progress of the ISB remedy toward meeting the performance criteria and RAOs and shall support agency 5-year reviews.

Additionally, quality assured sampling results will be submitted to the agencies as they become available, but no later than 120 days after sample collection. Non-quality assured data that support decision-making will be submitted as they become available. The formats for these submittals will be identified in the ISB Data Management TPR (TBD).

Data management and reporting activities will be conducted by the FTL, FLL, Data Entry Technician, In Situ Multi-Parameter Monitoring Probe Technician, SMO contact, Data Evaluation Lead, and Project Manager. The general roles of each are defined in the ISB HASP (INEEL 2002a), while specific responsibilities are defined in the ISB Data Management Procedure (TBD).

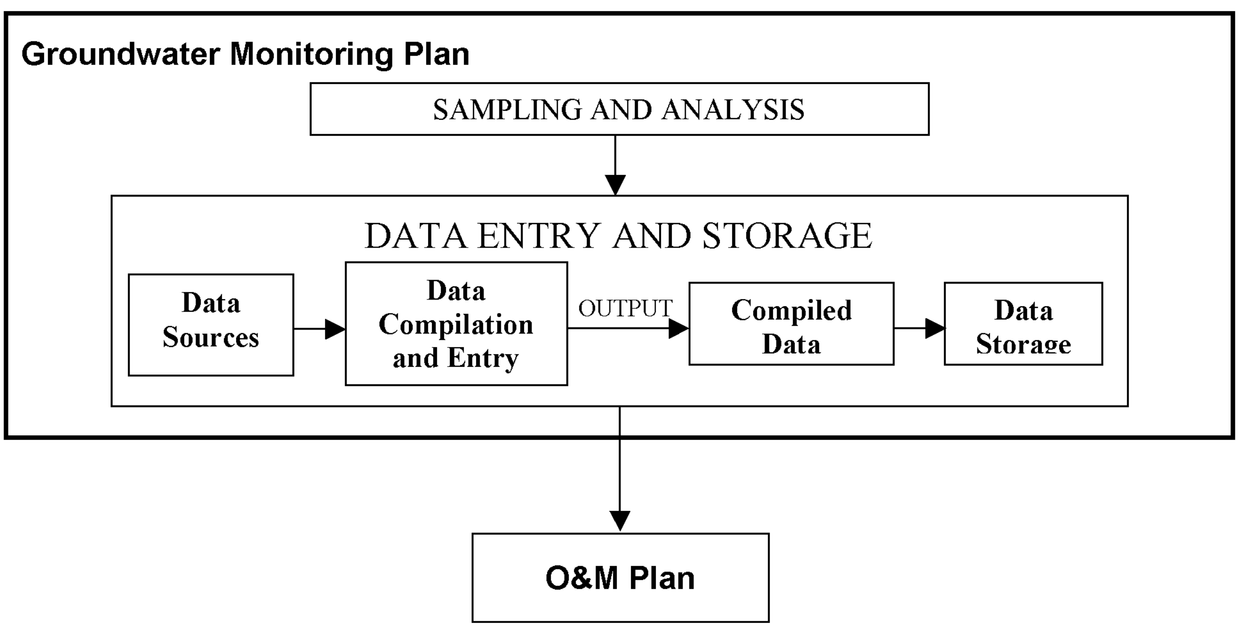

Figure 4. Data management process.

6. QUALITY ASSURANCE

This section presents or references requirements for QA, including field and laboratory QA types and frequencies; precision and accuracy; corrective actions; and reporting, for analyses performed in support of OU 1-07B ISB remedial action at the on-site field laboratory, the IRC laboratory, and off-site laboratories. Quality assurance will be implemented as specified in this plan, the QAPjP (DOE-ID 2000), PLN-694, "Environmental Restoration Program Management Plan," and TPR-166, "ISB Analyses Procedures."

For purposes of this groundwater monitoring plan, laboratory QA measures are those checks that an analyst routinely runs to determine precision and accuracy of the analytical methods and equipment (method error) and typically include blanks, standards, duplicates, standard reference materials (SRMs) and standard additions (matrix spikes). Field QA measures are sample types collected or prepared in the field during sampling and submitted to the laboratory to assess overall data quality of the sampling and analysis program (total measurement error). Field QA sample types include field blanks, trip blanks, and field duplicates. Compliance monitoring at TAN-28 and –30A, and at PMW-1 and –2 will be considered separate sampling events; for which one field blank, one field duplicate and one trip blank will be collected and analyzed for each respective well pair per sampling event.

Performance evaluation (PE) samples may be added to the OU 1-07B ISB Remedial Action QA program at the discretion of the ISB Technical Lead or Project Manager. If implemented, the PE program will be administered by the SMO with direction from the ISB Technical Lead regarding sample type, concentration ranges, frequency, and analytes for each performance period.

Data validation levels, as defined in the QAPjP, are identified in Section 6.3 for definitive off-site analyses only. Data from field laboratory or IRC analyses are not validated.

6.1 Field Laboratory

6.1.1 Laboratory and Field Quality Assurance

Laboratory QA for the on-site field laboratory includes analysis of blanks, duplicates, standards, and standard additions (matrix spikes). Procedures for preparing standards and standard additions, precision and accuracy requirements, and corrective actions for field laboratory internal QA checks are described in TPR-166.

Field QA includes the analysis of field blanks and field duplicates. Frequencies for field QA analyses are specified in Table 5.

6.1.2 Reporting

Control charts will be prepared and maintained for each QA parameter and analyte. The QA results will be evaluated and compiled as described in the ISB Data Management Procedure (TBD). Laboratory QA results and corrective actions will be summarized and reported in the ISB Periodic Report.

Table 5. Field QA frequency for ISB RA groundwater monitoring.

Sample Type	Frequency	Comments
Field Duplicate	1 per 20 samples[a,b]	All samples
Field blank	1 per 20 samples[a,b]	All samples
Trip blank	1 per sample cooler	For IRC VOCs and ethane/ethane methane and off-site samples only.
Definitive confirmation	Quarterly/annual performance sampling round	VOCs only

a: 1 sample for all analytes per day if number of monitoring locations is <20.
b: 1 sample per round for compliance monitoring at TAN-28 and –30A; and at PMW-1 and –2.

6.2 IRC Laboratory

6.2.1 Internal and Field Quality Assurance

Laboratory QA for the IRC laboratory includes analysis of blanks, duplicates, standards, and standard additions (matrix spikes). Procedures for preparing standards and standard additions; precision and accuracy requirements; and corrective actions for OU 1-07B ISB remedial action IRC laboratory analyses are described in the "OU 1-07B ISB Remedial Action IRC Analyses Procedures" (TBD).

Field QA includes the analysis of field blanks and field duplicates. Frequencies for field QA analyses are specified in Table 5.

6.2.2 Reporting

IRC QA results will be evaluated and compiled as described in the ISB Data Management Procedure (TBD). Control charts will be prepared and maintained for each QA parameter and analyte. Internal QA results and corrective actions will be summarized and reported in the ISB Periodic Report.

6.3 Off-site laboratories

6.3.1 Laboratory and Field Quality Assurance

Laboratory QA for the off-site laboratories includes blanks, duplicates, standards, and standard additions (matrix spikes). Off-site laboratory QA requirements established in the QAPjP are based on definitive data requirements (see Table 6).

Field QA includes field blanks, trip blanks and field duplicates. Frequencies for field QA analyses are specified in Table 5.

Table 6. Laboratory QA requirements for definitive data[a].

QA Parameter	VOCs	Parameter calculated
Precision		
Duplicates	TCE: ±14%	Relative percent difference (RPD)
Accuracy		
Standards	71-120%	% recovery
Matrix spikes	71-120%	% recovery
Completeness		
Definitive confirmation	90%	% complete
Compliance monitoring	100%	% complete

a: as defined by the QAPjP

6.3.2 Corrective Actions

Corrective action requirements are established by the SMO in the TOS for the performing laboratory.

6.3.3 Reporting

Laboratory reporting requirements for off-site laboratory QA are established by the SMO in the TOS for the performing laboratory. Off-site laboratory QA results will be evaluated and compiled as described in the ISB Data Management Procedure (TBD) and will be summarized and reported in the ISB Periodic Report.

6.3.4 Data validation

Definitive data from off-site analyses will be validated to Level A, as specified in the QAPjP.

7. REFERENCES

Bukowski, J. M., and K. S. Sorenson, 1998, "Site Conceptual Model: 1996 Activities, Data Analysis, and Interpretation for Test Area North Operable Unit 1-07B," INEL-97-0056, Idaho National Engineering and Environmental Laboratory, Idaho Falls, Idaho.

Bukowski, J. M., H. Bullock, and E. R. Neher, 1998, "Site Conceptual Model: 1997 Activities, Data Analysis, and Interpretation for Test Area North Operable Unit 1-07B," INEEL/EXT-98-00575, Idaho National Engineering and Environmental Laboratory, Idaho Falls, Idaho.

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INEEL, July 2000, *Field Evaluation Report of Enhanced In Situ Bioremediation, Test Area North, Operable Unit 1-07B*, INEEL/EXT-2000-00258, Revision 0, Idaho National Engineering and Environmental Laboratory, Idaho Falls, Idaho.

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MCP-3480, 2001, "Environmental Instructions for Facilities, Processes, Materials and Equipment," Rev. 6, June 1, 2001.

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TPR-165, "Low-Flow Groundwater Sampling," January 2002, Revision 5, Idaho National Engineering and Environmental Laboratory, Idaho Falls, Idaho.

TPR-166, "ISB Analyses Procedures," June 2001, Revision 4, Idaho National Engineering and Environmental Laboratory, Idaho Falls, Idaho.

TPR-4907, "Installation and Removal of Equipment in TAN Wells," April 2002, Revision 0, Idaho National Engineering and Environmental Laboratory, Idaho Falls, Idaho.

Wymore, R. A., J. M. Bukowski, and K. S. Sorenson, Jr., December 2000, *Site Conceptual Model:1998 and 1999 Activities, Data Analysis, and Interpretation for Test Area North Operable Unit 1-07B*, INEEL/EXT-2000-00188, Idaho National Engineering and Environmental Laboratory, Idaho Falls, Idaho.

7.1 Documents to be Prepared

INEEL, "Statement of Work for IRC Analyses in Support of OU 1-07B ISB," Idaho National Engineering and Environmental Laboratory, Idaho Falls, Idaho, TBD.

INEEL, "ISB Data Management Procedure for TAN Final Groundwater Remediation, OU 1-07B," Idaho National Engineering and Environmental Laboratory, Idaho Falls, Idaho, TBD.

INEEL, "OU 1-07B ISB Remedial Action IRC Analyses Procedures," Idaho National Engineering and Environmental Laboratory, Idaho Falls, Idaho, TBD.

TPR-TBD, "In Situ Multi-Parameter Monitoring Probe Operations," Idaho National Engineering and Environmental Laboratory, Idaho Falls, Idaho.

Appendix A

Example Sampling and Analysis Plan Tables

Appendix B

OU 1-07B ISB Monitoring Well Information

Table B-1. Construction details for OU 1-07B ISB groundwater monitoring wells.

Sample location	Well name	Well ID	Northing	Easting	Elevation at top of casing (ft above msl)	Well total depth (ft bls)	Screened interval(s) (ft bls)	Screen type	Pump type	Sampling depth (ft bls)	Pump discharge line or pipe diameter (in.)	Discharge line or pipe material	Length of discharge line (ft)	Estimated purge volume (gal)
TSF-05A	**ANP-03**	71	795401.63	356999.79	4782.00	310.00	180-244	p	RF2	235[a]	0.5	poly	275.00	9
TSF-05B		71	795401.63	356999.79	4782.00	310.00	269-305	p	RF2	275	0.5		275.00	9
TAN-10A		348	795239.78	356921.78	4780.70	250.00	216-250	ss	RF4, 5E8	238	1	ss	233.00	29
TAN-25		1117	795386.10	357019.30	4781.38	315.00	217-297	ss	RF4	218	1		218.00	27
TAN-26		1118	795372.30	357040.60	4781.93	412.00	369-409	ss	RF4	389	1		389.00	48
TAN-28		1008	795380.60	357261.00	4781.07	262.00	220-260	ss	RF4, 5E8	242	0.75	ss	241.50	17
TAN-29		1010	795330.80	357508.10	4782.68	265.00	222.25-262.25	ss	RF4, 16E4	253	1	ss	253.20	31
TAN-30A		1012	795363.60	357269.80	4780.62	320.90	299.90-319.90	ss	RF4, 5E8	313	0.75	ss	312.70	22
TAN-31	**TANT-INJ-A-003**	1219	795450.79	356995.05	4780.83	310.00	205-310	o	RF4	258	1	ss/galv	258.00	32
TAN-37A	**TANT-MON-A-011**	1163	795366.71	357144.97	4782.32	415.90	204-415.90	o		240	0.5	ss	250.00	8
TAN-37B		1163	795366.71	357144.97	4782.32			o		272	1	poly	275.00	34
TAN-37C		1163	795366.71	357144.97	4782.32			o		375	1	ss	375.00	46
TAN-D2		339	795505.95	356960.12	4779.89	262.00	116-126	p	RF4	242	1		241.00	30
							201-222	p						
							232-251	p						

a= pump on hose reel is raised to sample this location

p = perforated
poly = polyethylene
galv = galvanized
o = open hole
ss = stainless steel
RF2 = Grundfos RediFlo-2 pump
RF4 = Grundfos RediFlo-4 pump